

# *Job Market Paper*

## **Deposit Dollarization Dynamics**

### **In a Model of Network Externalities and Hysteresis:**

#### **The Case of Argentina**

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#### **Abstract**

The shift from peso to dollar denominated deposits (deposit dollarization) in Argentina is explained with a nonlinear model that incorporates network externalities, hysteresis and ratcheting effects. A depreciating currency like the peso imposes a holding cost and converting it to a safer brand imposes a switching cost. Furthermore, the currency choice of an individual is influenced by the choices which others in his/her reference group make. This is because the reward for joining a network increases nonlinearly as its size expands. Thus, network behavioral dynamics will move a given dollarization level along a nonlinear path to rest at an either high or low equilibrium point. At equilibrium, people are comfortable with the currency network they are in, even if the peso's exchange rate stabilized, a situation generally termed hysteresis. Hysteresis exists because dollar deposits are not subject to a holding cost while conversion to the peso imposes a switching cost and exposure to depreciation spikes. To establish a new equilibrium position, a shock affecting the holding cost of various currencies is needed. Peso's depreciation spikes increase its holding cost and ratchet up dollarization equilibriums. On the other hand, a strong contractionary policy that appreciates the peso can do the opposite. The model is found to have an empirical support in Argentina's history with financial dollarization. The model may also be adapted to explain competition patterns among industrial standards and technologies.

## Introduction

The importance of the “dollarization” phenomenon emanates from its impact on the ability of central banks to have an effective monetary policy. Domestic money supply becomes less stable if most of the citizens are relying on dollars and euros in their daily life rather than their failing local currencies (see Cohen '04). McKinnon ('01) observes that the dollar started to be used widely in Latin American domestic markets, first as a store of value and next as a medium of exchange of choice (see also Feige et al '03a, p52.) The shift from peso to dollar denominated deposits in Argentina’s banking sector documents the erosion of the store of value function of the peso.

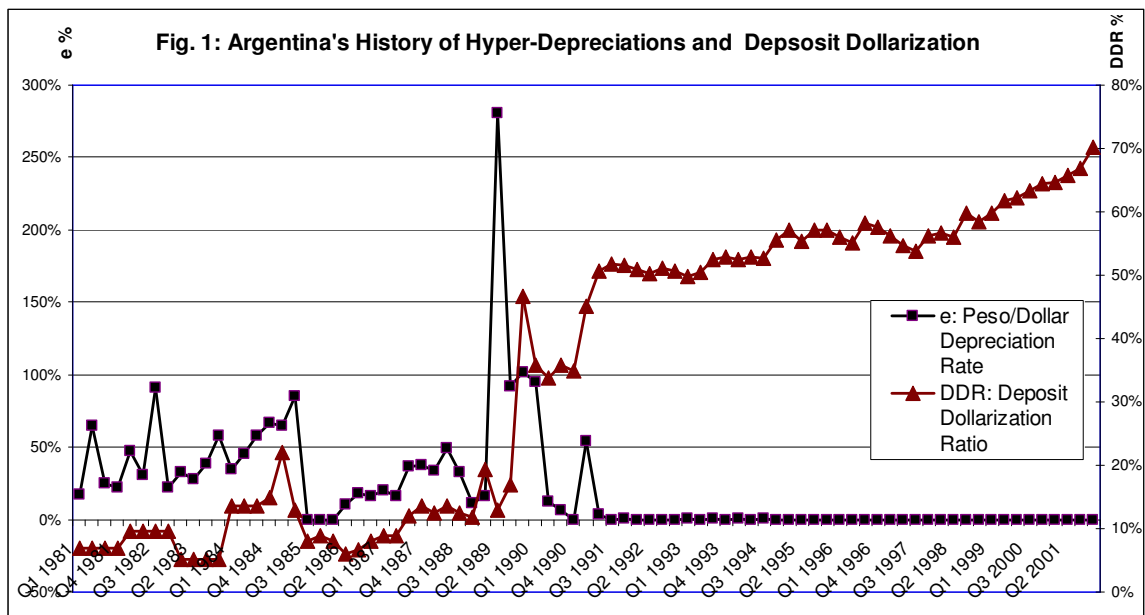


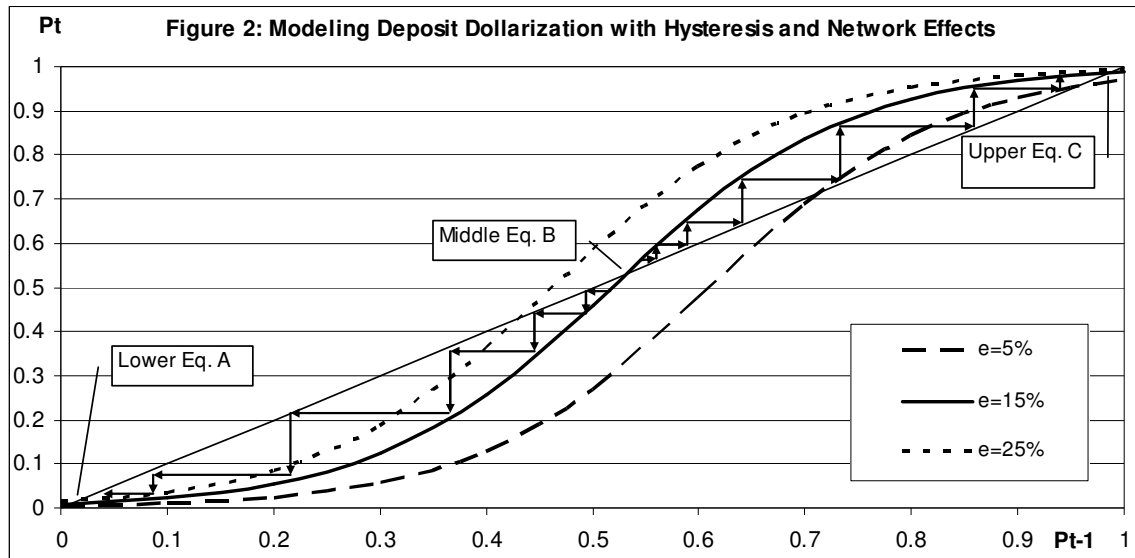
Figure 1 shows a succession of hyper-depreciation episodes<sup>1</sup> that drove the deposit dollarization ratio (DDR)<sup>2</sup> to experience rapid jumps. After the 280% quarterly free fall of the peso in Q2 '89, DDR rose from about 13% at the time to 47% by the end of '89. Later on, dollarization subsided to around 35% under a better controlled peso exchange value in the next year before another smaller depreciation bout. In the first quarter of '91,

<sup>1</sup> Depreciation (e) is measured by taking the log of The Argentine Peso/US Dollar quarterly market exchange rate,  $e = \ln(X_t/X_{t-1})$ .

<sup>2</sup> The terms deposit dollarization, asset substitution, store of value substitution or just dollarization are considered as synonyms throughout the paper.  $DDR = \text{Foreign currency deposits} / \text{total deposits}$ , see appendix B for discussion on data sources.

the Argentine peso (the peso) dropped again by 54% against the dollar. The drop was accompanied by a sharp increase in dollarization to over half of all deposits in the banking system. The following commitment to the stability of the peso with a currency board mechanism under the supervision of the International Monetary Fund (IMF) did not appear to have any effect on reducing financial dollarization in Argentina. If anything, dollarization has continued to climb up to the 70% level before the government forcibly converted all foreign deposits into pesos in '02.

In this paper, Oomes's ('01) model is modified and employed to explain Argentina's experience as depicted in Figure 1. Figure 2 below generically simulates the model, which relates asset substitution in the previous period ( $p_{t-1}$ ) to where it will be in the current one ( $p_t$ ). Deposit dollarization is at an equilibrium ( $p^*$ ) along the 45 degree line, where ( $p_t = p_{t-1}$ ). The main interesting outcome is that under the right circumstances, more than one steady dollarization state can exist in an economy, which supports the notion that steady equilibria ( $p^*$ 's) may not have a linear relationship with the rate of depreciation as portfolio balance models suggest.



Successive deteriorations in peso's exchange rate diminish the value of peso denominated savings and increase the cost of holding or using pesos as a store of value. Concerns about further purchasing power losses drive people to switch their savings to dollars. This is captured in the model by upward shifts in the dollarization path curves  $e=5\%$ ,  $15\%$  and

25% in figure 3. The model predicts that when depreciation rate ( $e$ ) increases from 5% to 15%, the dollarization curve jumps from the lower curve ( $e=5\%$ ) to the intermediate one ( $e=15\%$ .) However it does not fall back when depreciation returns to a 5% rate due to hysteresis effect. Hysteresis occurs when people expect hyper-depreciation episodes to continue even if the peso seems to have stabilized. Risk-averse agents do not adjust their depreciation expectation downward for fear of getting caught in another hyper depreciation episode. The middle curve in figure 3 also has three extreme values. While the upper and lower values (points A and C) are always stable the intermediate one (point B) is not<sup>3</sup>. Point B acts as a tipping point in the balance between the strength of rival currency networks that determine the transaction cost associated with using a currency. If the dollarization ratio passes point B ( $DDR > 55\%$ ) in the previous period, it will continue to rise until the upper equilibrium point (A) is reached. This is because the reward of joining the growing dollar network increases as the number of users rises.

This paper examines Argentina's history with deposit dollarization and finds that it can explain a good deal of the data trends in figure 1. In the next section I will discuss the theoretical approach of this paper and the model specification that generates figure 3. In section two, the data and empirical results used in Argentina's case study are reported and analyzed. The paper finishes in section three with an example of the policy implication of the model and a conclusion.

## **I. Theory and Model Setup**

### **A. Theoretical Approach**

Peoples attitude towards asset substitution is considered in light of two factors, holding and transaction cost that generates hysteresis and network externalities. Both factors have been considered in various ways in the literature to address the competition between local

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<sup>3</sup> The arrows depict how the upper and lower equilibriums are arrived at. For example, if asset dollarization at  $P_{t-1}$  is below point B but above point A, the level today will trend downward until it rests at point A.

and foreign currencies (pesos vs. dollars) over fulfilling the store of value function for money users.

Holding cost emphasizes the role of depreciation in diminishing the peso's purchasing power, especially when it is being held or saved over extended periods of time. For individuals or firms that rely heavily on the store of value quality of a currency, holding depreciating pesos for a long time imposes higher losses on them versus those who carry only short-term transactional balances of pesos. The loss varies positively with the rate of deterioration in peso's exchange rate, and with the size and the length of time a stock of pesos is held. According to Edmunds and Marthinsen ('03, p 12), agents experiencing hyperinflation may willingly keep on using small amounts of the local currency in daily purchases. However, the holding cost of a large amount of such currency is too much to bear. Agents experiencing hyperinflation adapt by converting their savings into a safer store of value, be it gold, dollars or euros (see also Melvin '88, p549-51.)

Transaction cost looks at the economic burden associated with moving money between two different denominations to pay for a product or a service. This cost exists whenever the preferences of buyers and sellers to transact with a certain brand of money differ or in other words they belong to different transactional networks. Belonging to a network produces externality gain to a user of a currency as the number of other users of the same currency expands. Network externalities influence those agents who place more weight on the transaction cost of a currency, which in turn depends on the decision of other agents to dollarize or not. Brock and Durlauf ('03, p235) argue that the "...payoff for a particular action is higher for one agent when others behave similarly" and "... the presence of social interaction will induce a tendency for conformity in behavior across members of a reference group. When social interactions act as strategic complementarities between agents, multiple equilibria may occur in absence of any coordination mechanism..." The resulting wide circulation of dollars in an economy makes it easy for local agents to adopt and use it, as Jameson ('03) notes. Dowd and Greenaway ('93) present an interesting model of currency network externalities with

increasing returns under conditions of perfect foresight. The perfect foresight assumption makes the model produce corner solutions, an outcome not commonly observed. It also does not allow a currency to be used as a store of value only without also being used as a medium of exchange<sup>4</sup>.

New in this research is the use of the “bandwagon effect,” from industrial standard rivalry literature, to provide stronger theoretical background for the model. David and Greenstein (‘90, p7) explain that “[the] Bandwagon effect is described as the processes by which decision makers overcome coordination problems in planning how to adopt a new standard, starting with those with largest private gain to those with largest network gains.” In the context of this paper, the band wagon concept suggests that those who have the highest prospect of loss due to private holding cost consideration will be the first to dollarize their savings. Those who do so later are motivated mainly by the size of the dollar’s transactional network. Thus, under the right conditions of holding and transaction cost, there is a strong path-dependence element in the wide circulation of international money brands like the dollar, euro and yen (See also, Matsuyama 1993, Jameson 2003, Ritter & Nicholas 2000, Greenspan 2000, Bergsten 2002, Eichengreen ‘05). Oomes’s currency substitution model (’03) and Feige’s et. al (’03) minor variation and application of the same model provide the underpinnings of the mechanism and econometric methodology for this paper. However, In order to analyze asset substitution problems, Oomes’s framework was extensively modified to admit multiple economic sectors, financial intermediation and different timing sequence to assure alignment between assumption and conclusions at the theory level. The model itself was enhanced by adding an interest rate differential variable and a different switching cost structure to better reflect the constraints on deposit accounts. The result is an Oomes model variation that is theoretically and empirically adapted to analyze deposit dollarization case studies. The rest of this section as well as appendix A will explain the above in more detail.

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<sup>4</sup> See also Dean’s (’00, p294) discussion of the role of transactional networks in currency competition.

## B. Model Setup and General Assumptions

In a simplified full capacity economy, there is a financial and a real side. The real side is made up of a large consumer goods sector (for example food) and a smaller durable good sector (for example cloth). In the food sector, transactions are conducted in pesos (a local currency) and thus income is also received in pesos. In the cloth sector, goods are purchased with saved assets making it suitable for analyzing asset substitution. Savings are denominated in either pesos or dollars (a foreign currency with a stable purchasing power.) To buy a cloth item, agents survey its price today and plan their savings with the goal of buying it at time  $t+1$ , following cash in advance constraint.

In the financial side of the economy, people use peso/dollar exchange rate information to determine the current real value of the peso in exchange for goods and services (see Calvo '01, p326)<sup>5</sup>. Prices and wages are dollar indexed to shield them from fluctuation in the real value of the peso<sup>6</sup>. Peso's depreciation is costly because of the diminishing value of its future purchasing power as dollar-indexed peso-prices of products rise (Kamin and Ericsson, '00, p185). Savers must make a decision that compares the holding cost of pesos and dollars versus their usefulness in transactions. A seller, in the other hand, prefers to hold money in the same denomination they transact in to avoid the cost of switching the money later.

Saver ( $j$ ) faces a holding cost over period  $t$  (the time between  $t$  and  $t+1$ ) and a transaction cost at time  $t+1$  that depends on a seller's ( $k$ ) currency choice at  $t+1$ . Positive network externalities arise when the money holding preferences of buying and selling agents are the same. The table below indicates the costs associated with agent  $j$ 's decision to save pesos ( $m$ ) or dollars ( $m^*$ ) at time  $t$  ( $m_{j,t} = m$  or  $m_{j,t} = m^*$  respectively) before being

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<sup>5</sup> The "fear of floating" concept deals with agents' expectations that floating is a cover for excessive money supply. McKinnon ('00, p119) notes the difficulty in relying on local indices "private debt contracts are seldom linked to domestic price indexes--such as the WPI or CPI--in part because of doubts over the statistical reliability of such indexes and because of lags in collecting price data."

<sup>6</sup> Price indexing, essentially, constitutes a substitution of monetary standards whereby the peso unit of account is replaced with the dollar unit of account. The modeling of this process is left for future research.

matched with a random seller  $k$  who has a unique preference to transact in either pesos ( $m$ ) or dollars ( $m^*$ ) at time  $t+1$  ( $m_{k, t+1} = m$  or  $m_{k, t+1} = m^*$  respectively.)

**Table 1: Cost Matrix for a Saver  $j$**

Saver $j$ preferences at ( $t$ )	Seller $k$ preferences at ( $t+1$ )		
		$m_{k, t+1} = m$ (pesos)	$m_{k, t+1} = m^*$ (dollars)
	$m_{j, t} = m$ (pesos)	$e - i$	$e + \sigma - i$
	$m_{j, t} = m^*$ (dollars)	$2\sigma - i^*$	$\sigma + q - i^*$

$m$  : pesos.

$m^*$  : dollars.

$i$  : interest rate on peso deposits

$i^*$  : interest rate on dollar deposits

$e$  : peso's depreciation rate.

$\sigma$  : switching cost between currencies.

$q$  : probability of confiscation.

In table 1, the cost of saving pesos when a seller  $k$  accepts them as a medium of exchange (both are in the peso network) is equal to  $e - i$  (upper left cell), the cost of depreciation minus the value he/she puts on the interest rate of return on peso saving deposits. If  $k$  deals in dollars only  $m^*$  (upper right) the peso savings of  $j$  will incur  $e - i$  as well as a switching cost  $\sigma$ <sup>7</sup>. Due to government sanctions, dollar holdings are exposed to a confiscation risk  $q$  if used in transactions<sup>8</sup> while they also receive a rate of return  $i^*$  while they are saved. The lower left cell shows also a double switching cost  $2\sigma$  incurred when a seller wants to use pesos; One  $\sigma$  when the peso denominated income of food makers is initially switched to dollar terms and another  $\sigma$  when they have to be switched back into pesos to fulfill a transaction. This second  $\sigma$  can be avoided if a seller is in the dollar network (lower right cell) and wants to receive his/her income in dollars despite the  $q$  risk involved. The cost of the durable good itself is normalized to unity.

<sup>7</sup> Switching cost stands for the extra effort needed to exchange one currency for another and any fees associated with such transaction.

<sup>8</sup> Or face other institutional barriers like having to transact in pesos in the food market, buying in small or remote markets where the dollar is less familiar and harder to exchange



Belonging to a network is beneficial when both  $j$  and  $k$  prefer to transact in the same money brand without regard to the merit, if any, of holding an alternative one. The peso brand enjoys positive network externality when its holding cost ( $e - i$ ) is less than ( $2\sigma - i^*$ ) the cost incurred in switching savings into dollars and back again into pesos so they can be used in transactions. The same happens to the dollar when the institutional cost involved ( $q$ ) is cheaper than the alternative cost of a depreciating peso savings ( $e$ ) after adjusting for transaction costs and return rates on savings<sup>9</sup>. A combination of the previous two conditions results in ( $\sigma > q$ ) which means that whenever transaction cost is larger than the confiscation rate, there is a benefit in joining a currency network to avoid this cost<sup>10</sup>.

### C. Best Response Functions

At time  $t$  agents do not know the exact values of the variables in table 1. They form expectations about peso's expected depreciation rate during  $t+1$  period at time  $t$ , expected switching cost and confiscation rate at time  $t+1$ . The expected values of the variables will be denoted as  $\hat{e}_t, \hat{\sigma}_{t+1}$  and  $\hat{q}_{t+1}$  respectively.

Let  $\hat{p}_{t+1}$  stands for the probability, expected by saver  $j$  that  $k$ , a randomly chosen seller, prefers to transact in dollars at time  $t+1$ . By choosing  $k$  at random,  $\hat{p}_{t+1}$  can stand for the expected percentage of agents holding dollars at  $t+1$ <sup>11</sup>, as measured by expected asset dollarization ratio at  $t+1$ <sup>12</sup>. From the information in table 1, the expected cost of holding pesos,  $c(m_t)$ , in the time period between  $t$  and  $t+1$  is

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<sup>9</sup> Refer to table 1. Peso's network externality condition is  $e - i < 2\sigma - i^*$  (Upper left cell < Lower left cell), and in the case of the dollar network it is  $\sigma + q - i^* < e + \sigma - i$  or  $q - i^* < e - i$  (Lower right cell < Upper right cell).

<sup>10</sup> This is similar to the presence of barriers against entry and exit into industries and in adopting a technology standard in industrial organization literature. A decrease in these barriers is key to creating contestable markets, where monopolist or oligopolist firms price like perfect competitors for fear of market share loss due to ease of entry and exit by opportunistic entrepreneurs.

<sup>11</sup> This treatment provides an important transition from the analysis of individual outcomes to economy wide outcomes.

<sup>12</sup> This is assuming that all savers have the same amount of either dollar or peso only savings.

$$\begin{aligned}
c(m_t) &= (1 - \hat{p}_{t+1})(\hat{e}_t - i_t) + \hat{p}_{t+1}(\hat{\sigma}_{t+1} + \hat{e}_t - i_t) \\
c(m_t) &= \hat{e}_t - i_t + \hat{\sigma}_{t+1}\hat{p}_{t+1}
\end{aligned} \tag{1}$$

And the cost expected for holding dollars,  $c(m_t^*)$ , will be:

$$\begin{aligned}
c(m_t^*) &= (1 - \hat{p}_{t+1})(2\hat{\sigma}_{t+1} - i_t^*) + \hat{p}_{t+1}(\hat{\sigma}_{t+1} + \hat{q}_{t+1} - i_t^*) \\
c(m_t^*) &= 2\hat{\sigma}_{t+1} + \hat{q}_{t+1}\hat{p}_{t+1} - i_t^* - \hat{\sigma}_{t+1}\hat{p}_{t+1}
\end{aligned} \tag{2}$$

Cost minimizing agents will hold dollars whenever  $c(m_t^*) < c(m_t)$  and will hold pesos if the inequality is reversed. There is still a possibility that agents may continue to prefer a currency for non-economic considerations that are observable to them only<sup>13</sup>. Let  $\varepsilon_{j,t}$  and  $\varepsilon_{j,t}^*$  represent these unaccounted for random utility (or disutility) variables<sup>14</sup> that affect the decision to hold pesos or dollars respectively by agent  $j$  at time  $t$ <sup>15</sup>. Let  $\varphi$  be a coefficient that measures the overall role of these variables on the total expected cost<sup>16</sup>. Now we can state the probability ( $p_{j,t}$ ) that a given agent  $j$  will save dollars during the period ( $t$  to  $t+1$ ) to be

$$\begin{aligned}
p_{j,t} &= \Pr \{ c(m_t^*) + \varphi \varepsilon_{j,t}^* < c(m_t) + \varphi \varepsilon_{j,t} \} \\
&= \Pr \{ \varepsilon_{j,t}^* - \varepsilon_{j,t} < \frac{1}{\varphi} [\hat{e}_t - i_t + \hat{\sigma}_{t+1}\hat{p}_{t+1} - 2\hat{\sigma}_{t+1} - \hat{q}_{t+1}\hat{p}_{t+1} + i_t^* + \hat{\sigma}_{t+1}\hat{p}_{t+1}] \} \\
&= \Pr \{ \varepsilon_{j,t}^* - \varepsilon_{j,t} < \frac{1}{\varphi} [\hat{e}_t + i_t^* - i_t - 2\hat{\sigma}_{t+1} - \hat{q}_{t+1}\hat{p}_{t+1} + 2\hat{\sigma}_{t+1}\hat{p}_{t+1}] \}
\end{aligned} \tag{3}$$

The model becomes econometrically estimable when the standard discrete choice theory<sup>17</sup> is applied to equation 3. Given that  $\varepsilon_{j,t}$  and  $\varepsilon_{j,t}^*$  are identically and

<sup>13</sup> Agents may hold pesos because of patriotic sentiment; believe the economy will improve soon...etc.

<sup>14</sup> The variables have a logistic distribution pattern.

<sup>15</sup> Feige et. al. ('03, p 60) explains that "In order to close the model and introduce a stochastic element that allows for non-corner solutions, Oomes uses the random utility terms  $\varepsilon_{j,t}$  and  $\varepsilon_{j,t}^*$  that account for unobserved variables effecting the cost or benefits of holding domestic and foreign currency."

<sup>16</sup> So  $\varphi(\varepsilon)$  is a random utility term, independently and identically distributed across agents. Agent  $j$  knows  $\varphi(\varepsilon)$  at the time of his/her decision.

<sup>17</sup> The theory uses a qualitative response model where the dependent variable is an indicator of a discrete choice, such as yes or no. In our case it is pesos or dollars (see Greene '03, p 663 and p 670 for discussion on random utility models.)

independently distributed (idd) across  $j$  and  $t$ <sup>18</sup> and have extreme value distribution<sup>19</sup>, the theory helps generate the following “best response function” to the discrete choice of dollarizing

$$p_{j,t} = (1 + \exp\{-\frac{1}{\sigma}[\hat{e}_t + i_t^* - i_t - 2\hat{\sigma}_{t+1} + (2\hat{\sigma}_{t+1} - \hat{q}_{t+1})\hat{p}_{t+1}]\})^{-1} \quad (4)$$

Equation 4 contains the following important properties: The probability that a given buyer  $j$  will choose to save dollars, given expected future dollarization levels  $\hat{p}_{t+1}$ , increases with the increase in expected depreciation cost  $\hat{e}_t$ , a decrease in the gap between  $i_t^* - i_t$ <sup>20</sup> ( $\hat{I}_t$  will stand for the expected impact of interest rate differential  $R = i_t^* - i_t$ ) and decrease in institutional barriers  $\hat{q}_{t+1}$ .

Interestingly,  $\hat{\sigma}_{t+1}$ 's influence changes depending on the value of  $\hat{p}_{t+1}$ . If the expected dollarization ratio at  $(t+1)$  is low  $\hat{p}_{t+1} < .5$ , an increase in expected switching cost  $\hat{\sigma}_{t+1}$  will depress dollarization levels today  $p_t$ . If on the other hand  $\hat{p}_{t+1} > .5$ , an increase in future switching cost will encourage dollarization today<sup>21</sup>.

The best response function is positively sloped as  $p_t$  is increasing in  $\hat{p}_{t+1}$  whenever our assumption  $\hat{\sigma}_{t+1} > \hat{q}_{t+1}$  holds.

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18 This is assuming that  $\varepsilon_{j,t}$  and  $\varepsilon_{j,t}^*$  are logistically distributed in the following form:

Prob ( $\varepsilon - 1 - \varepsilon(1) \leq x$ ) =  $[1 + \exp(-\beta x)]^{-1}$ , see Brock and Durlauf ('01, p239).

19 “Extreme value distributions are the limiting distributions for the minimum or the maximum of a very large collection of random observations from the same arbitrary distribution.” (*NIST/SEMATECH e-Handbook of Statistical Methods*)

20 The longer a stock of pesos is held (n time periods) and the higher the rate of depreciation is, the higher is its holding cost.  $i_t^* - i_t$  is expected to be a negative sum since rates of return on local currencies usually add a country risk premium. Thus, larger negative  $i_t^* - i_t$  sums should lessen pesos account losses or make peso accounts more attractive and vice versa.

21 Switching cost behavior may be interpreted in the following manner: at low levels of dollarization, dollar savers are expected to bear a cost close to  $2\sigma$  (when asset substitution is nil,  $p_t = 0$ ) and thus the effect of depreciation is reduced by about  $2\sigma$ . On the other hand, at high expected dollarization levels the

## D. Expectations

From the above analysis, agents' currency choices are found to depend on the expected values of  $(\hat{e}_t, \hat{q}_{t+1}, \hat{\sigma}_{t+1}, \hat{I}_t \text{ and } \hat{p}_{t+1})$ . With a sufficiently large pool of agents, the law of large numbers allows  $p_t$  or the overall dollarization ratio at time  $t$  to equal the probability that a random agent is holding dollars ( $j_{i,t} = p_t$ ) for all  $j$  and  $t$ .

But how are these expectations formed? If we assume perfect foresight then people have perfect knowledge of the level of asset dollarization today from their perfect information of the next period. In other words,  $p_t$  simply becomes a function of  $\hat{p}_{t+1}$ , and in turn  $\hat{p}_{t+1}$  becomes a function of  $\hat{p}_{t+2}$  and so on or  $p_t = \hat{p}_{t+1} = \hat{p}_{t+2} = p^*$  ( $p^*$  is a constant dollarization equilibrium level.) Assuming that agents are fully informed about distant future events in this fashion is unrealistic and leads to corner solutions.

Alternatively, agents can have static expectation, whereby the status quo is assumed to persist with variables remaining at their previous levels ( $\hat{x}_{t+1} = x_t$ ) for all variables except  $\hat{p}_{t+1}$ <sup>22</sup>. For example, buyers predict that dollarization level to be similar to the one they experienced in their last shopping trip, so  $\hat{p}_{t+1} = p_{t-1}$ . The simplified assumptions listed above will be the subject of further treatment when the regression model is discussed. For now, the following law of motion is generated<sup>23</sup>:

$$p_t = (1 + \exp\{-\frac{1}{\phi}[e_t + I_t - 2\sigma_{t+1} + (2\sigma_{t+1} - q_{t+1})p_{t-1}]\})^{-1} \quad (5)$$

Equation 5 permits us to predict how the dollarization of the store of value will evolve over a certain time period, given the values of the principle variables  $(\hat{e}_t, \hat{q}_{t+1}, \hat{\sigma}_{t+1}, \hat{I}_t)$ . If these principal variables remain unchanged, the dollarization ratio of asset will converge to a steady state  $p^*$  that solves  $p_t = p_{t-1}$  for all  $t$ . This also indicates that changes in

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switching cost burden is almost taken away from dollar savers (the cost is 0 when  $p_t = 1$ ). In other words, the increase in switching cost for peso holders is influenced by the high probability of incurring it.

<sup>22</sup> "This assumption is considered reasonable in cases where agents repeatedly encounter similar situations" (Oomes, '03, p16).

<sup>23</sup> Oomes's equation is  $p_t = (1 + \exp\{-1/\phi [e_t - \sigma_t + (2\sigma + \tau_t - q_t)p_{t-1}]\})^{-1}$

$(\hat{e}_t, \hat{q}_{t+1}, \hat{\sigma}_{t+1}, I_t)$  will alter the asset substitution equilibrium as well. In this modification of Oomes's model we can also experiment with different values for the above fundamental variables to examine their impact on deposit dollarization equilibrium in an economy, as was done in the introduction.

### III. Empirical Estimation

#### A. Estimation Procedure

The nonlinear structural form equation of the model (eq. 5 above) can be linearized by logistic manipulation to produce the equation below<sup>24</sup>:

$$\ln\left(\frac{1-p_t}{p_t}\right) = -\frac{1}{\phi}[e_t + I_t - 2\sigma_{t+1} + (2\sigma_{t+1} - q_{t+1})p_{t-1}] \quad (6)$$

The dollarization ratio  $p_t$  is assumed to be bounded between 0 and 1.  $\ln\left(\frac{1-p_t}{p_t}\right)$ , the log

odds ratio range of values is not restricted. Given these information the ordinary least squares (OLS) estimate procedure can be used under the following assumptions:

First, there is no data on the confiscation risk variable  $q_t$ . Following Oomes's assumption,  $q_t$  is left constant for convenience throughout the sample period ( $q_t = q$  for all  $t$ .) This makes it possible to find a simplified estimate for  $q$ .

Second, admittedly there are no precise and well documented data on switching or transaction costs. But it is reasonable to expect switching cost ( $\sigma$ ) to decrease as dollarization becomes more prevalent in the economy. The increasing demand for dollars encourages more foreign exchange kiosks to open, which will increase competition and reduce transaction costs to dollar users. Hence,  $\sigma$  can be given the following functional form:

$$\hat{\sigma}_{t+1} = 1 - \gamma p_{t-1} \quad (7)$$

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<sup>24</sup> For derivation steps see appendix C.

Switching cost  $\sigma_t$  is net of the value of a product, which is set to 1 (i.e. unity).

Third,  $I_t$  stands for the impact, measured by  $\zeta$ , of interest rate differentials ( $R_t = i_t^* - i_t$ ) on deposit dollarization. So we have:

$$I_t = \zeta R_t \quad (8)$$

Citizens in financially vulnerable economies “... frequently require extra compensation to voluntarily hold their own money in deposit because they view it as an inferior brand.” (Von Furstenberg, '00, p21.) Just paying interest rates on peso deposits may not be enough to convince people to let go from the safety of dollarized savings. Equation 8 attempts to measure the influence of interest rate differential on foreign versus locally denominated accounts on the choice between them.

Fourth, expectations about pesos depreciation can be the product of a number of factors. Using the “expectational adjustment periods” approach<sup>25</sup>, agents will be assumed to predict peso's depreciation rate correctly with probability  $\alpha$ , and with probability  $(1 - \alpha)$  they predict that depreciation will be equal to its highest rate in the recent past, thus employing a ratchet effect. Hence, the expected rate of peso depreciation will be

$$\hat{e}_t = \alpha e_t + (1 - \alpha) e_t^{\max} \quad (9)$$

Where  $e_t^{\max} = \max\{e_t, \dots, e_{t-n}\}$  is, as in Oomes ('03, p19) is the source of ratcheting<sup>26</sup>.

The final addition that is needed to arrive at an estimable reduced-form equation<sup>27</sup> is an error term  $v_t$  to account for errors. Equation 7, 8 and 9 are substituted for their respective variables in equation 6 to produce:

$$\ln\left(\frac{1-p_t}{p_t}\right) = \frac{2\gamma_1}{\phi} - \frac{\zeta}{\phi} R - \frac{\alpha}{\phi} e_t - \frac{(1-\alpha)}{\phi} e_t^{\max} - \frac{(2\gamma_2 + 2\gamma_1 - q)}{\phi} p_{t-1} + \frac{2\gamma_2}{\phi} p_{t-1}^2 + v_t \quad (10)$$

<sup>25</sup> This approach stands for the realization that it takes time before agents become convinced that a present macroeconomic stability is of permanent nature, see Peires and Wrase, 1997, Oomes 2003, p9. Other explanations incorporate transaction and learning cost.

<sup>26</sup> “Thus, expectation formation is assumed to be a linear combination of perfect foresight and the ratchet effect” Feige et. al. ('03, p 60.)

<sup>27</sup> For a discussion of reduced form equation properties see Studenmund '01, ch14.

Which, can be written as

$$\ln\left(\frac{1-p_t}{p_t}\right) = \beta_0 + \beta_1 R + \beta_2 e_t + \beta_3 e_t^{\max} + \beta_4 p_{t-1} + \beta_5 p_{t-1}^2 + v_t \quad (11)$$

Where

$$\begin{aligned} \beta_0 &= \frac{2\gamma_1}{\varphi} & \beta_1 &= -\frac{\zeta}{\varphi} & \beta_2 &= -\frac{\alpha}{\varphi} & \beta_3 &= -\frac{(1-\alpha)}{\varphi} \\ \beta_4 &= -\frac{(2\gamma_1 + 2\gamma_2 - q)}{\varphi} & \beta_5 &= \frac{2\gamma_2}{\varphi} \end{aligned}$$

The restriction ( $\beta_0 = -2(\beta_2 + \beta_3)$ ) is needed to avoid multiple estimates for  $\varphi$ .

## B. Data

The data covers the time span between Q1 '81 and Q1 '01. The International Financial Statistics (IFS) database of the International Monetary Fund (IMF) and Central Bank of Argentina' banking sector information were the principal sources of regression data. Other minor sources were also used to obtain deposit dollarization readings. Appendix B provides further discussion on these other sources.

## C. Statistical Results

The econometric equation used to study deposit dollarization in Argentina is

$$\ln\left(\frac{1-DDR}{DDR}\right) = \beta_0 + \beta_1 R + \beta_2 e + \beta_3 em1.5 + \beta_4 DDR1 + \beta_5 SqDDR1 + v_t \quad (12)$$

The dependent variable (LDDR) is the log odd ratio of deposit dollarization ratio. The independent variables are: the interest rate differential (R), exchange rate depreciation (e), maximum exchange rate in the past year and a half (em1.5), One quarter lagged deposit dollarization ratio (DDR1) and the square of it (SqDDR1). A nonlinear regression

model was used to run equation 12 with ( $\beta_0 = -2(\beta_2 + \beta_3)$ ) restriction. Values of the estimated coefficients are reported in table 2.

Table 2: Parameter Estimates

Parameter	Estimate	Std. Error	t-value	P
b0 (Const)	3.149	.108	29.2067	0.000
b1 (R)	-1.058	.155	-6.8223	0.000
b2 (e)	-1.429	.208	-6.8837	0.000
b3 (em1.5)	-.145	.054	-2.6785	0.007
b4 (DDR1)	-7.706	.970	-7.9435	0.000
b5 (SqDDR1)	2.838	1.462	1.9417	0.050

Table 3: Goodness of Fit and Residual Tests

R <sup>2</sup>	0.947	DW - D	1.837
Adj R <sup>2</sup>	0.944	1 <sup>st</sup> Order Autocorr	0.079
F(5, 79)	427.75	p	0.000
Jarque-Bera	67.716	p	0.000

As can be seen from table 2, all variables appear to be significant and have the correct signs. From Table 3, The Jarque Bera test of normal residual distribution is also significant. However, as is the case with financial or macro data, autocorrelation and nonstationarity are common challenges to the validity of the reported t-values and the associated significance levels. Whether or not the estimates in Table 2 are worthwhile depends on how much error is involved in generating them. Most of the reported t-values are significant at a level higher than 99%. Hence, a serious threat to the estimates can probably be ignored.

The values of the coefficients in table 2 are used to find the values of the structural variables in the model, which are found to equal:



Table 4: Structural Values

$\phi$	<b>0.635</b>	$\gamma$	<b>0.9</b>	$\zeta$	<b>0.67</b>
$q$	<b>-1.09</b>	$\alpha$	<b>0.91</b>		

The  $\gamma$  value of .9 suggests that even when the economy arrives at full dollarization, there still will be a switching cost of about .10 (see eq. 7.) But this persisting switching cost is mostly incurred by those who did not join the dominant dollar network. The presence of an official sector that collects taxes and fees in pesos can explain why the local currency will continue to be used. A  $\zeta$  value of .67 indicates that agents discount the rate of return on peso deposits by .33 due to the depreciation risk associated with the peso. This can be to account for the risk premium on local deposits. Agents predict the depreciation rate ( $e$ ) accurately about .91 of the time and the rest of the time they are exposed to unexpected losses. Interestingly, the institutional barrier or the confiscation rate is actually negative indicating a possibility of not loss but a 100% windfall gain over the period of the regression out of holding dollars. One way to interpret this puzzling result is to refer to the large losses which peso denominated deposits endured especially in the 80's. In one incident in 1993, the Argentine government, for a short time, froze peso rather than dollar deposits to prevent further flights to the safety of the dollar. This move came during a speculative doubt over the Argentina's commitment to the one to one convertibility plan (backed by a currency board) after Brazil devalued its currency.

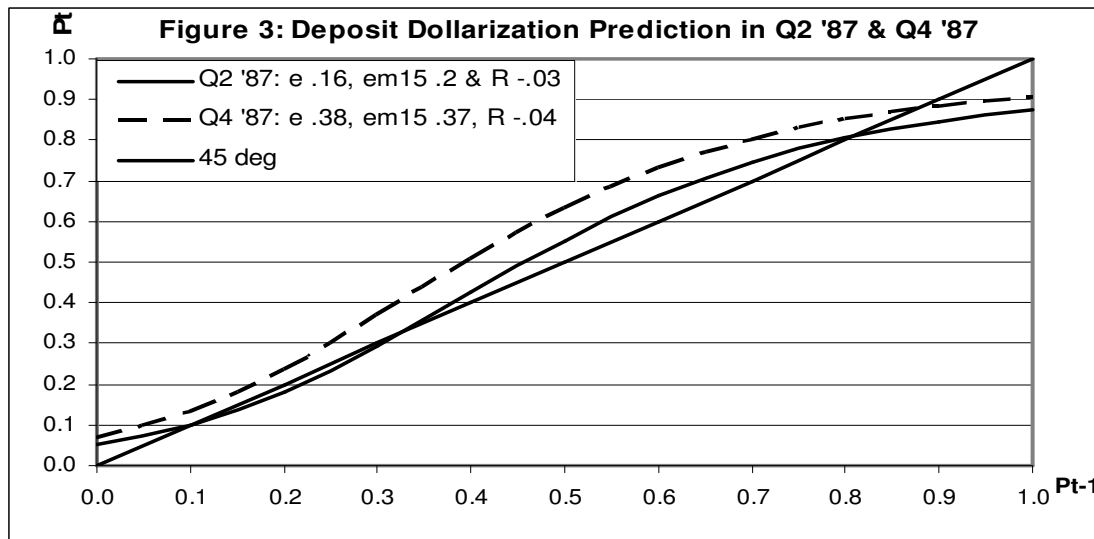
## D. Interpretation:

Predicted dollarization paths are generated with the use of the estimated reduced-form equation (13)

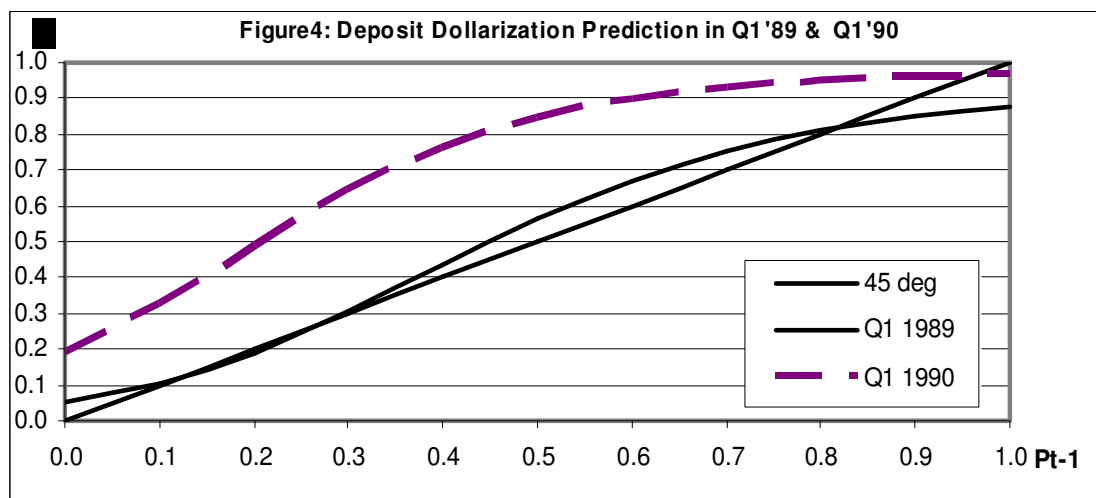
$$p_t = (1 + \exp\{3.1 - 1.1R - 1.4e - 0.1em1.5 - 7.7DDR1 + 2.8SqDDR1\})^{-1} \quad (13)$$

This equation is plotted below in Figures 3 and 4 by using  $e$ ,  $em1.5$  and  $R$  information from several key time periods. Figure 3 creates two estimated dollarization paths, using

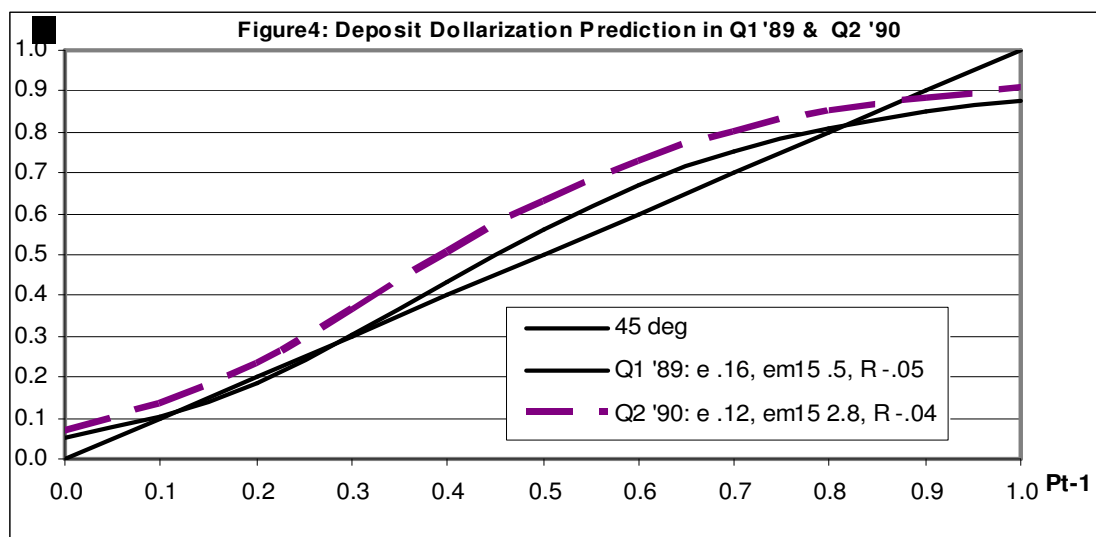
information before and after the 280% hyper depreciation episode in the third quarter of '87.



One can see that the lower curve of Q2 '87 has three equilibrium points (like the ones in figure 2) with a stable equilibrium at the upper and lower points. The deposit dollarization ratio (DDR) was very low at about .09, right about the lower equilibrium. However, a near doubling in the depreciation rate shifted the curve upward. The higher dollarization path of Q4 '87 has only one high equilibrium point at about a DDR of .87. According to the model, the economy will start an adjustment process that will move it into near full dollarization. The high depreciation rate of the peso in the third and fourth quarter of '87 coupled with very low interest rate of return exposed peso holders to massive losses that outweighed the network advantage which the peso enjoyed initially. The DDR ratio of .12 at the time will move upward unless the peso is quickly stabilized. Actually the whole currency was replaced and the new Argentine currency was called the Austral.



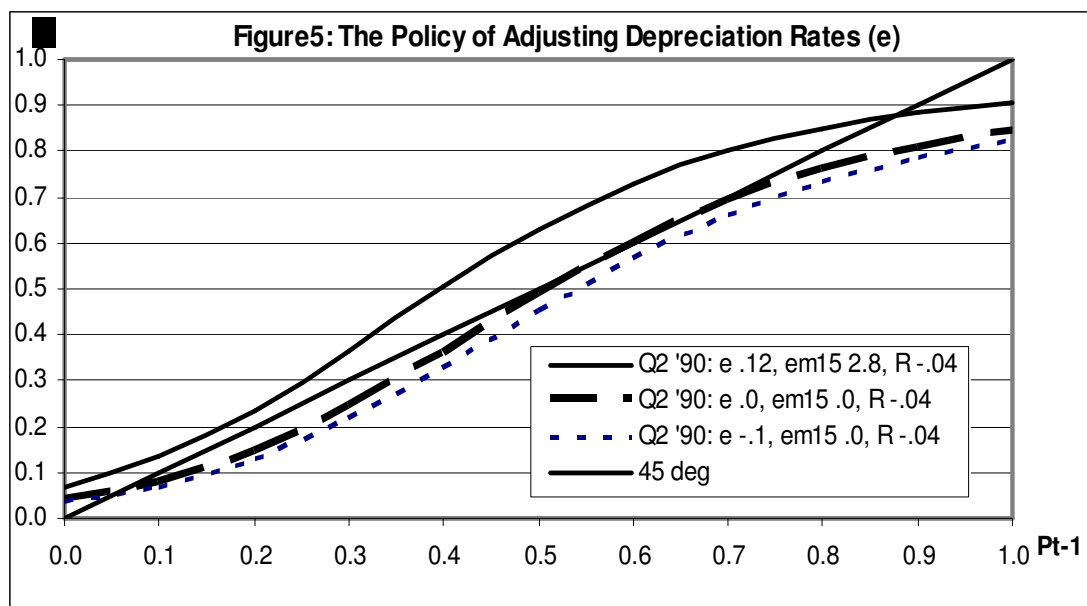
After two years of mild ups and downs in the Austral's exchange rate versus the dollar, a massive realignment took place and the rate rose by about 280% in Q2 '89. Again, with a DDR of about .12 the dollarization of the financial sector could have been controlled at that level if Austral was to credibly stabilize. The event of Q2 '89 however ratcheted up the path. The DDR ratio was .36 in Q2 '90 and the dollarization curve did not have any lower steady state. Simply stabilizing the exchange rate at that point was also fruitless because of the already significantly dollarized depository system. Notice that shifting downward to the previous curve will not help restore the lower equilibrium point because the dollar network has gained enough momentum to pass the intermediate point, which was about .3 DDR. Hence, during the 90's asset substitution marched onward steadily with the help of the growing transactional network of the dollar. Replacing the Austral with the new Argentine peso came too late to remedy the situation.



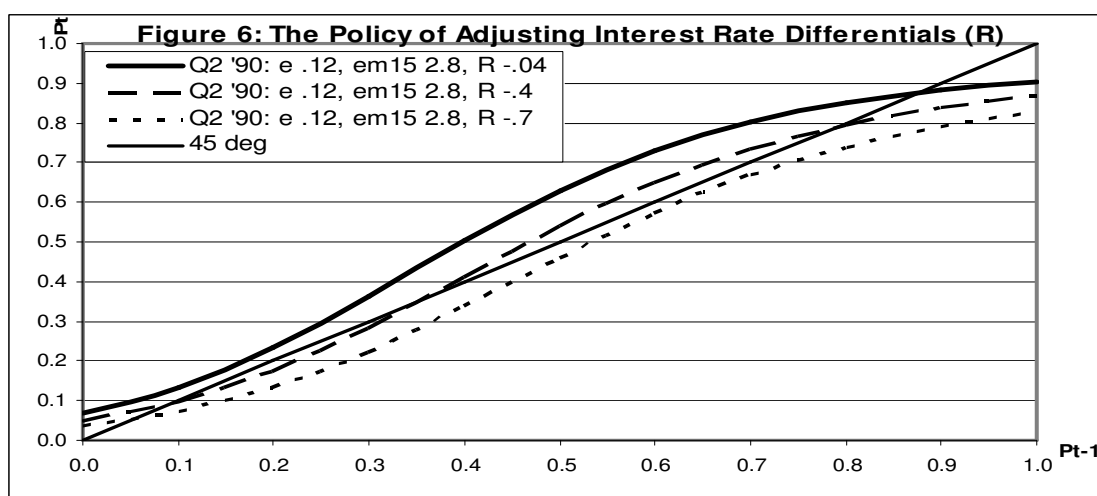
Figures 3 and 4 provide useful insights not only for academic or speculative purposes but also for suggesting possible policies to deal with high incidents of asset substitution. In the next section, possible policy measures are discussed followed by a conclusion.

### III. Policy Suggestions and Conclusion

The position of the curves in all dollarization paths is governed by regression coefficients. Of these coefficients, decision makers may be able to manipulate two, the depreciation rate ( $e$ ) and interest rate differential ( $R$ .) The next two figures will discuss what happens if  $e$  or  $R$  are adjusted. Figure 5, display three dollarization paths. The upper one is the actual one and it is the same curve that was discussed in figure 4. This curve can be shifted downward if depreciation rate is severely curtailed. The intermediate curve demonstrates that simply having no depreciation at all will succeed only in bringing down DDR from an .88 to .7 equilibrium but a low equilibrium is still not achievable. Notice that .7 percent is also the level which DDR was by Q1 '02. It takes a really bold move to appreciate the peso by about .1 to entice the bulk of dollar depositors to switch back to the peso. In this case, agents will switch because of the reward to hold pesos rather than its defunct network advantage.



Alternatively, figure 6 give policy makers the ability to reduce asset substitution by increasing the dividends on the peso brand. Again, we can see if  $R$  is reduced from  $-.04$  to  $-.4$  (an interest rate hike of about 36%) the curve shifts down and help reduce the intersection point of the upper equilibrium but not much. It will take an  $R$  of about  $-.7$ , or a hike of about 75% on local deposits to tip the balance of the store of value function in favor of the peso. After the curve ratchets down enough, the dynamics of the peso network gain momentum and can restore both the store of value and the medium of exchange functions to the Argentine peso.



## **Conclusion**

The deposit dollarization model in this paper is found to have support in the empirical results from Argentina's banking sector. It also helps to link the transition from asset to currency substitution and back again. This is done by stressing the role of holding and transaction factors that are influenced by private cost minimizing function and the collective preferences of the rest of the society.

An interesting extension to the model will be to discuss the role of the unit of account function of money in driving dollarization. It was assumed in this paper that prices and wages are indexed to the dollar, which means that effectively the peso has lost its ability to assign values to goods and services independently from other unit of accounts. This can be termed a unit of account substitution or dollarization. If saving sums are allowed to vary, then holding cost consideration and hysteresis effect is expected to be stronger for large savers.

This paper dealt with deposit dollarization as a defacto market-promoted process without delving into a debate over the merits or demerits of the outcomes. Yet, the model should prove to be a useful framework for both sides of the debate to examine and test the impact of their arguments and policy positions.

## Appendix A: Model Assumption

The model assumes an economy with two sides: real and financial. In the real side, there are two sectors, the first is for consumer goods (food) and the second is for durable goods (clothes), which is the focus of the paper. The financial side facilitates the clearing of markets through an inter-temporal distribution of resources over the two real sectors, as it will soon be explained.

There are 100 agents<sup>28</sup>, 80 are involved in making food and the other 20 produce clothes. A producer in the first sector makes one food unit (1 FU). Workers need to consume .8 FU in each period. Total food production is 80 food units (80 FU) per time period of which 64 FU will be consumed by food producers and the rest (16 FU) are needed for the consumption needs of clothe makers. A worker in the second sector requires 5 time periods to finish one clothe unit (1 CU). An individual requires .2 CU every 5 time periods. Total production is 20 CU every 5 time periods, of which 4 CU will go to the clothe makers and the other 16 CU will be demanded by food makers. Over five time periods total supply is 400 FU and 20 CU, which equals total demand (sector I demand is 320 FU + 16 CU and sector II demand is 80 FU + 4 CU) and the real exchange ratio is 1 CU = 5 FU (inter-sector trade is 80 FU for 16 CU.) A peso unit of account is established at an exchange rate of 1 CU per peso<sup>29</sup>.

Total income in this economy is generated and spent in proportion to employment ratios in each sector. Representative producers from the two sectors generate all their income from their respective sectors. Both representatives spend their income in the same manner with 80% going to food purchases and the other 20% to clothes<sup>30</sup>. Buyers are subject to cash-in-advance constraint, so that before being matched with a random seller, they must hold enough money to buy the product they want.

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<sup>28</sup> The numbers used here are for clarification purpose only.

<sup>29</sup> A peso monetary standard can be established by choosing an anchor commodity (an ounce of gold = one peso) or .8 FU as in this paper. Afterward, the relative scarcity of gold/food versus other commodities sets their peso prices.

Income is generated when a product is sold. This creates a problem because a person in the second sector does not sell his/her clothes until time period five ( $t_5$ .) If agents in the second sector cannot buy food then agents in the first market can not make money to buy clothes by  $t_5$  and we have disequilibrium in both markets. Since food producers make 1FU and need to consume .8 of it at a time, they can extend a consumer credit line to cloth producers (directly or through an intermediary) to allow them to consume the remaining .2 FU. With a 20% saving rate in the consumer goods sector, there is just enough food credits to support the food consumption of those in the clothing industry, hence, full employment equilibrium is maintained.

A financial authority<sup>31</sup> is established to manage the credit system by providing saving accounts and extending consumer credit. Each food producer saves .2 FU (= .04 peso) a period and each clothes producer borrows .8 FU (.16 peso) a period. Total credit supply (.04x80= 3.2 pesos) and demand (.16x20= 3.2 pesos) per period is equal.) This economy now has an established monetary standard (the peso)<sup>32</sup>. Initially, the peso is used to conduct all transactions and fulfills all of the three functions of money for local agents<sup>33</sup>.

The dollar is a rival monetary standard, a credit system managed independently from those who manage the peso system. The dollar is also available to local agents and its

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<sup>30</sup> This indicates a marginal propensity to consume (MPC) of .8 and a marginal propensity to save (MPS) of .2, which means that an agent consumes 80% of it (or 80 cents) and saves the remaining 20% (or 20 cents) of every dollar they earn.

<sup>31</sup> With the help of a bank, savers put their money in no-interest bearing accounts. Producers of durables in turn can access zero interest credit lines in the meantime to finance their purchases of consumer goods. When these latter agents receive their pay, they will spend it all in the following manner, 80% to pay back consumer credit balances and the remaining 20% on other durable goods of their choice. Therefore, the economy enjoys full employment. Precisely, the leakage is equal to 16% of the national income. This leakage is equal to consumption demand in the durable goods sector (80% of 20% of the economy is 16%.)

<sup>32</sup> Agents use money to facilitate economic transactions because monetized transactions are more efficient than barter. Barter suffers from the two problems of double coincidence of wants and proportionality in exchange.

<sup>33</sup> Historically, central banks had a monopoly over money supply within the political boundaries of an economy. Globalization reduced the effectiveness of political boundaries and brought about an increased competition from foreign goods and services. A monetary standard ultimately provides a service to its users. Competition between different monetary standards creates an oligopolistic framework for currency competition (See Cohen '04).



exchange rate is set to 1 dollar = 1 peso = 1 CU<sup>34</sup>. Savers can choose to have their saving accounts denominated in either dollars or pesos but to do so they have to incur a switching fee ( $\sigma$ ). In order to cover its currency position, the banks liability dollarization exposure will be matched by dollarized credit terms<sup>35</sup>.

When agents are given a choice between two brands of money, overall utility is maximized with the use of the more efficient (cost minimizing) one. Legally, the peso is the only tender allowed in market transactions. It's dominance as a medium of exchange in the food market is not challenged<sup>36</sup>.

However in the clothes market, dollar network effect develops as clothe makers borrow in dollar terms. These borrowers also develop a preference to transact in dollars to keep an alignment between the terms of income and the terms of their credit. They do so with an eye on the transaction cost (switching fee involved in exchanging one currency for another) and institutional barriers that exist at the time. The institutional barrier in this instant is a prohibition on using dollars to buy or sell clothes. Those who do so expose themselves to confiscation of the dollar sum involved. People make their purchases in full with either pesos or dollars.

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<sup>34</sup> The dollar can be assumed to be supported by a foreign government or even a local private issuer.

<sup>35</sup> Dollar denominated loans have cheaper rates than loans denominated in local currencies due to asymmetric information (lemons problem) with uninformed lenders and high cost of information with informed lenders (McKinnon '00, p112, see also Von Furstenberg, 2000). Calvo ('01, p316) relates liability dollarization to the standard requirement that banks have to match the money denomination of their assets and liabilities to avoid currency risk.

<sup>36</sup> Because, for example, it provides the needed small change to carry small transactions.

## Appendix B: Data

The data covers the time span between Q1 '81 and Q1 '01.

The rate of depreciation was calculated by taking the natural log of quarterly exchange rate ( $\ln(X_t/X_{t-1})$ ) as reported by the series below.

Argentine per US Dollar: End of Period (ae) Market Rate	218..AE.ZF...
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Deposit dollarization ratio (DDR) was calculated as the ratio of Total Private Foreign Deposits total Total Private Deposits. The data were obtained mainly from Argentina's Central Bank (BCRA) covering the period from Dec 1989 to Jan 2006. For dollarization data from the early eighties, I referred to monthly dollar deposit ratios as reported in graphs in Kamin and Ericsson's 2003 and 1993 papers. In an email, Ericsson stated that the data in his graph came from BCRA and Carta Economica (CE), a claim I could not verify independently.

Interest rate differential ( $R = \text{Deposit Rate (Fgn.Currency)} - \text{Deposit Rate}$ )

Deposit Rate	Percent per annum	21360L..ZF...
Deposit Rate (Fgn.Currency)	Percent per annum	21360L.FZF...

Deposit dollarization index (DDI) used the series in the table below, in the following manner:  $DDI = \frac{\text{of which: Fgn. Currency Deposits}}{(\text{Demand Deposits} + \text{Time, Savings, \& Fgn. Currency Dep.})}$

Demand Deposits	National Currency	Millions	21824...ZF...
Time, Savings, & Fgn.Currency Dep.	National Currency	Millions	21825...ZF...
of which: Fgn. Currency Deposits	National Currency	Millions	21825B..ZF...

## Appendix C:

Appendix E: Deriving equation 6 from 5.

$$p_t = (1 + \exp\{-\frac{1}{\varphi}[e_t + I_t - 2\sigma_{t+1} + (2\sigma_{t+1} - q_{t+1})p_{t-1}]\})^{-1} \quad (5)$$

$$p_t = \frac{1}{1 + \exp\{-\frac{1}{\varphi}[e_t + I_t - 2\sigma_{t+1} + (2\sigma_{t+1} - q_{t+1})p_{t-1}]\}}$$

$$1 - p_t = 1 - \frac{1}{1 + \exp\{-\frac{1}{\varphi}[e_t + I_t - 2\sigma_{t+1} + (2\sigma_{t+1} - q_{t+1})p_{t-1}]\}}$$

$$1 - p_t = 1 - \frac{1}{1 + \exp\{-\frac{1}{\varphi}[e_t + I_t - 2\sigma_{t+1} + (2\sigma_{t+1} - q_{t+1})p_{t-1}]\}}$$

$$1 - p_t = \frac{\exp\{-\frac{1}{\varphi}[e_t + I_t - 2\sigma_{t+1} + (2\sigma_{t+1} - q_{t+1})p_{t-1}]\}}{1 + \exp\{-\frac{1}{\varphi}[e_t + I_t - 2\sigma_{t+1} + (2\sigma_{t+1} - q_{t+1})p_{t-1}]\}}$$

So,  $\frac{1 - p_t}{p_t} = \exp\{-\frac{1}{\varphi}[e_t + I_t - 2\sigma_{t+1} + (2\sigma_{t+1} - q_{t+1})p_{t-1}]\}$

$$\ln\left(\frac{1 - p_t}{p_t}\right) = -\frac{1}{\varphi}[e_t + I_t - 2\sigma_{t+1} + (2\sigma_{t+1} - q_{t+1})p_{t-1}] \quad (6)$$

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